DLG Test Report 6263F

Stela Laxhuber GmbH

AgroDry®
MDB-XN 2/16-SB Continuous Dryer

Drying output and energy demand

DLG FOKUS TEST

04/15 Drying output and energy demand

Test Center
Technology and Farm Inputs

www.DLG-Test.de

Overview

The FokusTest is a smaller-scale DLG usability test intended to allow product differentiation and special highlighting of innovations in machinery and technical products used primarily in agriculture, forestry, horticulture, fruit cultivation and viticulture, as well as in landscape and municipal management.

This test focuses on testing a product's individual qualitative criteria, e.g. fatigue strength, performance, or quality of work.

The scope of testing can include criteria from the testing framework of a DLG SignumTest, the DLG's extensive usability test for technical products, and concludes with the publishing of a test report and the awarding of a test mark.

The DLG FokusTest "Drying systems" includes testing of the quality and suitability of a drying system. The criteria "drying output and energy demand" provide information on the system's level of throughput and how much energy this requires.

Other criteria were not investigated.

Assessment – Brief Summary

Testing of the continuous dryer yielded good results with regard to throughput and specific thermal energy demand.

Because of the operator's mode of operation and the available conveying technology, the capabilities of the dryer were not fully exploited and the intended throughput was not achieved.

Table 1:
Summary of results

Drying output		**Evaluation***
Throughput		
Dry product (operating conditions)	18.80 t/h	N/E
Dry product (standard conditions)	19.46 t/h	○
Wet product (operating conditions)	24.77 t/h	N/E
Wet product (standard conditions)	25.40 t/h	○
Moisture reduction in maize grains	20.7 % (from 34.9 % to 14.2 %)	N/E
Water removal from maize grains	5.94 t/h	N/E
Energy demand		
Energy demand per t of wet product		
– thermal	215.7 kWh/t	+ +
– electrical	8.5 kWh/t	+ +
Specific energy demand per t of water removed	922 kWh/t (3,319 kJ/kg)	+ +
Air flow rate per t of wet product	~6,300 m³	+ +

Comments

Standard conditions: drying from 35 % to 15 % moisture content in ambient conditions of 5 °C, 80 % relative humidity and 1013 mbar.
The measured values were determined at a hot-air temperature of 132 °C and 135 °C respectively. The design temperature is 125 °C.

* Evaluation range: + + / + / ○ / – / – – (○ = sandard, N/E = not evaluated)

The Product

Manufacturer and Applicant

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Product:
AgroDry® MDB-XN 2/16-SB
continuous dryer

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Description and Technical Data

The AgroDry® MDB-XN 2/16-SB continuous dryer from Stela Laxhuber GmbH dries the drying product using a feed-through method.

The fresh product passes through the two drying columns from top to bottom. The air flows into and out of the product flow through the ducts located in the column roofs. The warm supply air flows into the product flow through a roof duct. The product is therefore heated and releases its moisture into the air. This cools the air and increases its water content before it flows back out of the product flow through an exhaust duct. The air is drawn through the drying columns using a total of four fans.

The tested system is equipped with STELA Biturbo technology. In this air flow pattern, the drying product in the lower section of the drying system (lower drying section) is combined with blended air consisting of fresh air, which is drawn in and heated using a gas line burner, and preheated supply air from the cooling zones. This blended air is drawn in through two axial fans and then fed into the upper section from the lower drying section. At this point, heated fresh air is added to the blended air once again. This new blended air is combined with the drying product in the upper drying section. The air for the upper drying section is drawn in by two radial fans and discharged back into the environment after the drying product has flowed through and particulate matter has been removed.

This air flow pattern aims to use the wet drying product to clean the air in the upper drying section and therefore to reduce dust formation. Furthermore, this technique considerably reduces the amount of air required.

The dryer is designed for drying maize and, according to the manufacturer, is suitable for drying all grain crops.

Table 2:
Technical data (manufacturer's data)

Product data	
Description	Maize*
Bulk density (wet)	750 kg/m³
Loading moisture	35 %
Final moisture	15 %
Design data	
Hot-air temperature	125 °C
Ambient temperature	10 °C
Ambient humidity	50 % RH
Output data	
Wet product throughput	approx. 32 t/h
Dry product throughput	approx. 24.5 t/h
Water evaporation capacity	approx. 7.5 t/h
Dryer data	
Dryer capacity	154 t**
Active dryer capacity	133 t**
Dimensions L x W x H	14.8 m x 7.8 m x 23.9 m
Connected electrical load with particulate removal	224 kW

Fans		
Installation type	Exhaust air fan	Intermediate air fan
Number	2	2
Drive power per fan	75 kW	37 kW
Maximum air output	2 x 98,500 m³/h	2 x 81,500 m³/h
Nominal exhaust air output	159,800 m³/h	
Air heater		
Model	Maxon Natural Gas Line Burner	
Heating medium	Natural gas	
Calorific value	10 kWh/m³ in standard conditions	
Maximum output	2 x 5.1 MW	
Fire-alarm equipment		
Model	BME 20	
Exhaust air purification		
Model	2 x ZA 80 Centro Separators	

Comments
* Cleaned, biologically mature wet product
** At a bulk density of 750 kg/m³

The drying system was tested at a farm in the district of Passau. Testing was conducted from 14 to 20 October 2014. The farm uses natural gas to heat the dryer, which is used to dry a wide range of crops. In this testing process, the drying of maize was evaluated.

The good weather and the appropriate time of testing resulted in ripe, high-quality grain maize.

In order to determine the drying output, a calibrated vehicle scale was used to weigh the total amount of dried maize grains during the test. Furthermore, samples were taken from the fresh and dry product in order to determine the moisture content of the maize.

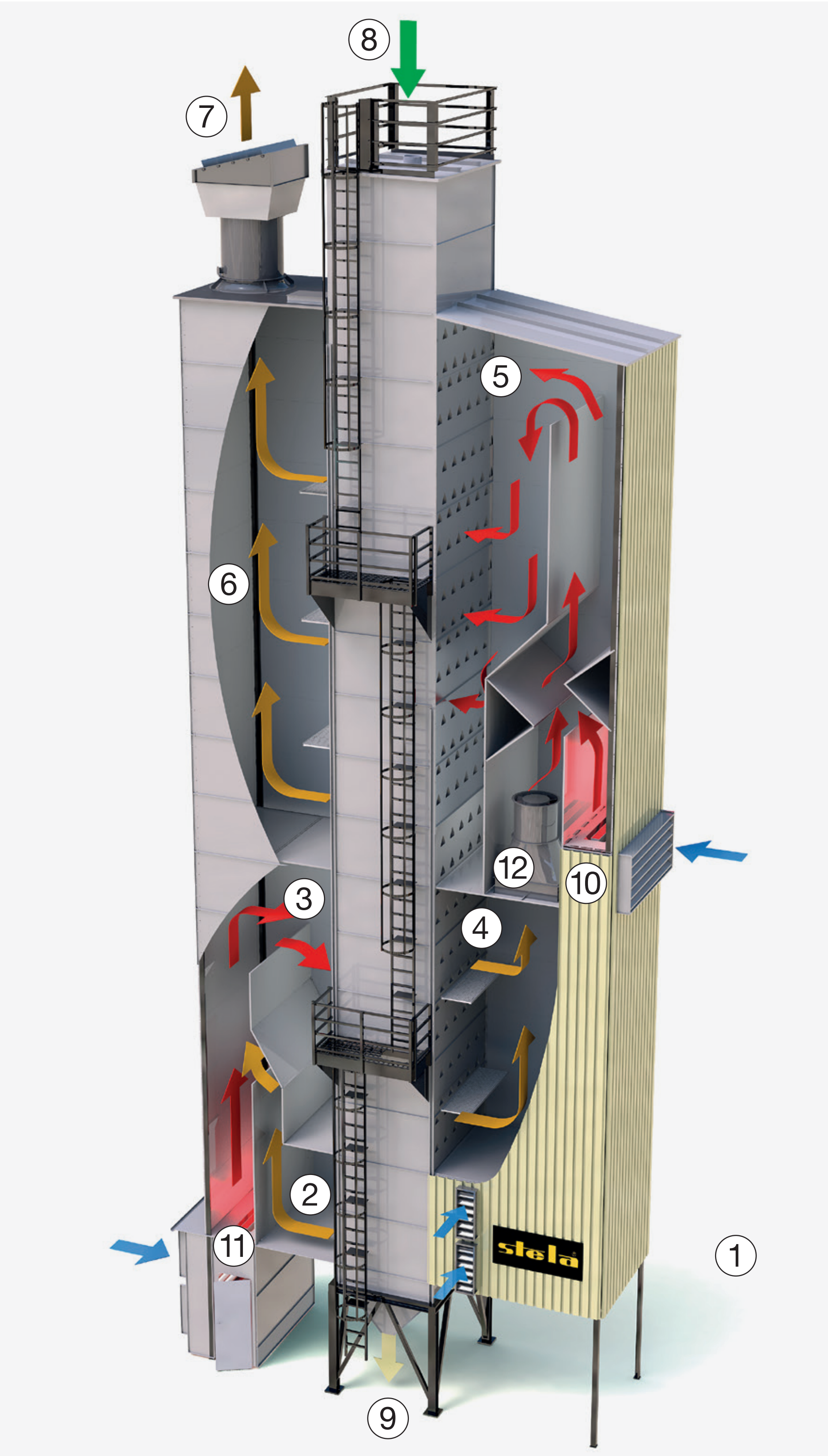

Figure 2:
Schematic representation of the dryer

The throughput of dry product ($\dot{m}_{DP}$) is calculated by dividing the mass of dry product (m_{DP}) by the time required for drying (t); see overviews 1 and 2.

$$\dot{m}_{DP} = \frac{m_{DP}}{t}$$

The throughput of wet product ($\dot{m}_{WP}$) is calculated from the throughout of dry product and the moisture levels determined for the dry and wet product (F_{DP} and F_{WP}).

$$\dot{m}_{WP} = \dot{m}_{DP} \times \frac{1 - F_{DP}}{1 - F_{WP}}$$

The dryer outputs ($\dot{m}_{DP}$ and $\dot{m}_{WP}$) can be used to calculate the water removal ($\dot{m}_{W}$).

$$\dot{m}_{W} = \dot{m}_{WP} - \dot{m}_{DP}$$

The thermal energy usage was determined using a gas flow meter.

The air flow rates were determined using differential pressure measurement in conjunction with a fan characteristic curve.

In a dryer with a capacity of approx. 154 tonnes, at a throughput of approx. 20 t of dry maize per hour, one must take into account an average time delay of usually at least 10 hours or two drying cycles until a stable operating level is established. According to the manufacturer, this delay time can vary depending on the system and the weather conditions.

The quoted output data has already been converted to standard conditions. The respective analyses began after a steady operating state was established and extended over approx. 10 hours for each cycle. For the sake of clarity, this test report does not present all of the test cycles.

Table 3 on page 6 summarises the results of the test. The values with a blue background are measurements; the other values were calculated or determined.

Mode of operation

The system was operated in a manner that meant the drying was too strong throughout the trial period. The moisture content of the dried maize was frequently below 14 %. Although the values shown in Table 3 for thermal energy demand were corrected for these circumstances, it can be assumed that the system's throughput would have been higher.

The drying system is operated manually, and the product's input and/or output moisture content is not controlled. The moisture of the incoming product is also not determined. These circumstances mean the system's capabilities are not fully utilised.

The manufacturer stipulates that higher temperatures be applied in the lower drying section than in the upper section. During the test, a supply air temperature of 130 °C or 135 °C was configured in the lower drying section. The temperature in the upper drying section was always 15 K lower, i.e. 115 °C and 120 °C respectively.

Throughput

The system throughput was calculated to be 19.46 t of dry product per hour when drying from 35 % to 15 % maize moisture content and at an ambient temperature of 5 °C. This required 25.40 t of fresh grain maize to be provided each hour. This corresponds to an hourly water removal rate of 5.94 t.

Energy demand

During the test, an average heat output of 5,477 kW was introduced into the dryer. This means that, per tonne of fresh product, 215.7 kWh of thermal energy was required to dry the product. At the same time, water was evaporated at an average rate of 5.94 t per hour, meaning 3,319 kJ were required to evaporate a kilogram of water (which corresponds to 922 kWh/t).

Theoretically, 2,382 kJ of energy are required to evaporate a kilogram (approx. 1 litre) of water at a grain temperature of 50 °C and an air pressure of 1,013 mbar. Taking into account the efficiency of a convective drying system, the determined values are assessed as very good.

The average electrical energy demand was 211.7 kW. Per tonne of fresh product, therefore, it was necessary to supply 8.5 kWh of electrical energy. This value is also very good.

Temperatures in the dryer

As an example, Figure 3 shows temperature curves in the dryer during a testing cycle from 2 a.m. to 6 a.m. The stable operating level results in very low variation in temperatures.

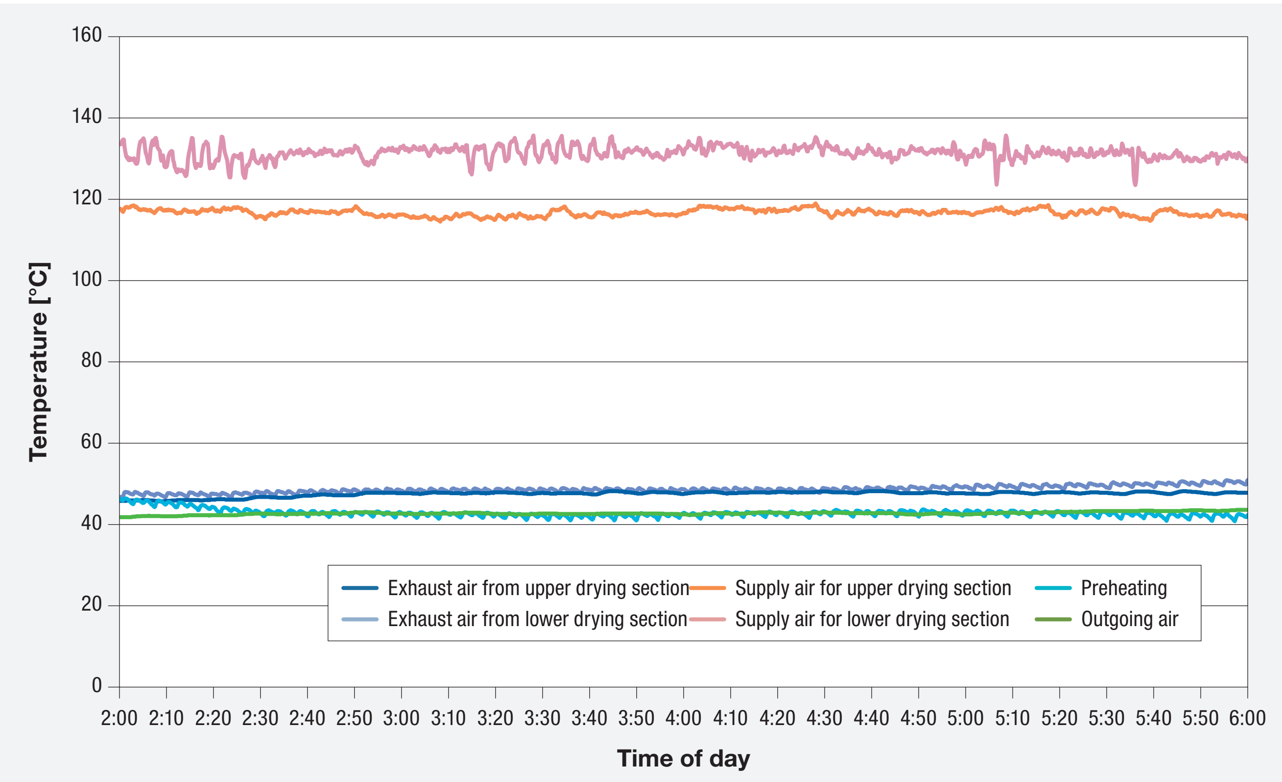

Figure 3:
Graphical representation of the temperatures in the dryer [°C]

Table 3:
Overview of measured and calculated values

	Position in diagram (Figure 2)			
Date		**15–16 October 2014**	**17–18 October 2014**	
Drying product		**Maize**	**Maize**	
Testing period		**21:07–06:13**	**20:03–05:43**	
Duration		**9.10**	**9.67**	**h**
Amounts of drying product				
Drying product, total (dry)		171.06	191.46	t
Drying product, total (wet)		225.45	242.70	t
Environmental conditions				
Rel. ambient humidity	1	93.2	94.3	%
Ambient temperature	1	12.5	12.2	°C
Ambient pressure	1	992	1004	mbar
Supply air temperatures				
Preheating	2	46.2	47.8	°C
Hot air, bottom	3	131.6	135.3	°C
Intermediate air	4	50.3	51.5	°C
Hot air, top	5	116.5	121.9	°C
Air conditions				
Relative humidity, outgoing air	7	80.2	80.5	%
Relative humidity, exhaust air	6	78.2	74.2	%
Outgoing air temperature	7	42.7	44.0	°C
Exhaust air temperature	6	47.4	48.7	°C
Maize moisture content, mean values				
Moisture content of wet product	8	34.9	32.0	%
Moisture content of dry product	9	14.2	13.8	%
Moisture removal		20.7	18.2	%
Throughput				
Dry	9	18.80	19.80	t/h
Corrected to standard conditions		19.46	18.02	t/h
Wet	8	24.77	25.10	t/h
Corrected to standard conditions		25.40	23.52	t/h
Water removal				
W.r.t. standard conditions		5.94	5.50	t/h
Gas consumption (operating volume)				
Burner, top	10	317.1	326.4	m³/h
Burner, bottom	11	230.6	230.9	m³/h
Total		547.7	557.3	m³/h
Specific value w.r.t. dry product		28.2	30.9	m³ of gas/t
Specific value w.r.t. wet product		21.6	23.7	m³ of gas/t

Position in diagram (Figure 2)				
Heat output/energy				
Burner, top	10	3171.0	3264.0	kW
Burner, bottom	11	2306.0	2309.0	kW
Total		5477.0	5573.0	kW
Specific value w.r.t. dry product		281.5	309.3	kWh/t
Specific value w.r.t. wet product		215.7	237.0	kWh/t
Energy required per volume of water				
Operating conditions		921.9	1013.0	kWh/t
Operating conditions		3319.0	3646.8	kJ/kg
Correction for maize temperature		79.1	73.2	kJ/kg
Correction for air temperature		234.5	243.1	kJ/kg
Standard conditions (5 °C)		992.9	1075.5	kWh/t
Standard conditions (5 °C)		3574.4	3871.9	kJ/kg
Pressure difference				
Radial fan 1	7	2262	2303	Pa
Radial fan 2	7	2247	2285	Pa
Axial fan 1	12	925	904	Pa
Axial fan 2	12	860	857	Pa
Air throughput				
Radial fans	7	154,000	154,000	m³/h
Axial fans	12	80,750	80,750	m³/h
Exhaust air volumetric flow rate	7	154,000	154,000	m³/h
Specific value w.r.t. dry product		7,915	8,547	m³/t
Specific value w.r.t. wet product		6,064	6,548	m³/t
Electrical power				
Mean values		211.7	211.7	kW
W.r.t. to 1 t of wet product		8.5	8.4	kWh/t

Comments

Standard conditions: drying from 35 % to 15 % moisture content in ambient conditions of 5 °C, 80 % relative humidity and 1013 mbar

Summary

Based on these results, the AgroDry® MDB-XN 2/16-SB continuous dryer from Stela Laxhuber GmbH meets the requirements of “Standard” (○) or better and for the awarding of a DLG FokusTest mark with respect to the testing criteria included in the “Drying output and energy demand” test. The dryer is therefore fundamentally suitable for drying maize.

Further Information

Further reports on tested drying systems are available to download at: **www.dlg-test.de/trocknung**

Test execution

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DLG Testing Framework

"Drying systems" FokusTest
(revised 09/2013)

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Indoor operations

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The DLG

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